Before the
FEDERAL COMMUNICATIONS COMMISSION
445 12th Street, S.W., TW-A325
Washington, DC 20554

Docket 04-186

In the Matter of

Unlicensed Operation in the
TV Broadcast Bands

Incremental Reform Towards a Broadcast Underlay, and the Radio Traffic Signal
Jon M. Peha

Jon M. Peha
Professor of Electrical Engineering and Public Policy
Associate Director, Center for Wireless and Broadband Networks
Carnegie Mellon University

Address: Carnegie Mellon University
Department of Electrical and Computer Engineering
Pittsburgh, PA 15213-3890
Phone: (412) 268-7126
Email: peha@cmu.edu
Web: www.ece.cmu.edu/~peha

November 26, 2004

Abstract

Exclusive licensing with an underlay is an appropriate paradigm for TV and other broadcast applications. Although further research is required on the viability of the more sophisticated forms of opportunistic access to insure the protection of TV signals, there are ways that a secondary device could safely use a broadcast band today. Thus, the FCC could move incrementally forward, allowing the underlay with sharing techniques that are known to be safe. This submission also suggests that the FCC consider certifying *radio traffic signals* as a viable approach. Underlay applications should also be reconsidered. We are more likely to see wireless last-mile connections than Wifi-like applications emerge in a broadcast underlay.

Introduction

I commend the FCC for considering the possibility of unlicensed operation in TV broadcast bands. In the debate over this issue, we have seen arguments that unlicensed operation is or is not inherently better than other regulatory paradigms, and that an underlay in any form does or does not violate some divine right that many license-holders (and not just broadcasters) would like to have. These are distractions from the immediate decision. To relieve spectrum scarcity, we must somehow allow more transmissions in bands that are already used for other applications. The question is whether this underlay is the best way to expand use of broadcast spectrum, without causing unacceptable levels of interference to TV signals. It is clear that some forms of underlays are possible without interfering with TV. These underlays may lead to the creation of new products or services, although we can never know in advance what the market will produce. Lack of harm and the possibility of benefit could be sufficient to begin allowing devices to operate in an underlay.

Some commenters have correctly pointed out that some approaches under consideration may not adequately protect the (licensed or unlicensed) incumbent spectrum users. There are complex technical issues to address. These technical concerns are reason to move slowly and incrementally, but they do not preclude movement.

Below, I will discuss the benefits of an underlay in spectrum used by broadcasters, and the types of applications that could emerge in an underlay, which are not the Wifi-like devices many people are suggesting. I will then discuss how TV signals can be protected, including the new *radio traffic signal.*

The Benefits of a Broadcast Underlay

Regulation of a band should fit the applications running in that band [1]. In a band containing TV or radio broadcasters, a regulator should grant licenses that allow broadcasters to transmit from specific locations, with an underlay for other uses. Broadcasters are well-served by

licensing, because they need the quality of service (QOS) guarantees that licensing can provide. However, broadcasts inevitably leave coverage gaps that could be used for other purposes. These gaps occur in locations that are sufficiently far from any transmitter ("white space"), and they even occur relatively close to the broadcasters' transmitters in cities with hills and other obstructions. No evidence has been presented that broadcasters could use those gaps any more effectively than a new entrant, so an underlay is the best option. Moreover, because broadcast transmitters are fixed and signals change little from second to second or hour to hour, it is easier to develop secondary devices that safely transmit opportunistically in these bands than in many others.

The FCC could either allow unlicensed devices to operate in the underlay, or it could assign licenses to operate in the underlay in a given region [2]. The latter would make it possible to limit the number of secondary devices competing for spectrum, reducing useful activity but potentially decreasing interference and congestion problems. Which of these approaches is most appropriate depends on what applications are most likely to emerge. Regulators should not prohibit clever entrepreneurs from developing novel products, but they should also avoid producing rules that are inconsistent with the products that are most likely to succeed.

The Right Applications for this Underlay

Any application that prospers in the underlay must be an appropriate complement to broadcast television. We must keep in mind that broadcast spectrum is used far more heavily in rural areas than urban. Furthermore, there is a greater degree of uncertainty in TV bands due to plans to the potential transition to digital technology.

For no obvious reason, much of the discussion of underlays has focused on applications similar to Wifi - *applications that do not belong in this band*. There have been reports of severe congestion in unlicensed bands that support Wifi, and that congestion is likely to grow. However, the regions experiencing this congestion are also regions that are well-covered by TV broadcasters. The predominately rural areas where much more broadcast spectrum sits idle already have ample spectrum for Wifi. Moreover, Wifi-like devices that operate in the underlay are likely to be more costly than their counterparts in unlicensed bands, because of the added complexity of avoiding TV signals and the smaller number of devices that manufacturers would produce. Finally, while some consumer products could certainly emerge in the underlay, consumer products may not be the best fit. A consumer might have to investigate to determine whether an underlay product could operate in her home.

A more promising application is broadband Internet access. The areas with the most unused broadcast spectrum are also the areas with the least competition from DSL and cable modem systems. In addition, devices might be sold through wireless Internet service providers (WISPs), who have the resources and expertise to understand the spectrum requirements, both before and after the digital TV transition. The WISP can guarantee that if a consumer cannot use a device in the intended location, the WISP will take back the equipment (and transfer it to someone else).

If consensus emerges that broadband connections to WISPs are indeed the most likely application to succeed in the underlay, this implies that different rules should govern the band than if Wifi-like devices are the focus. For example, secondary devices may need to operate at greater powers than would be expected from Wifi-like products. Smart antennas may become more practical. If higher powers are allowed, there is more reason to consider requiring an etiquette. A good etiquette can give device designers incentive to create spectrally efficient devices. In addition, if the number of secondary devices becomes large in a given area, a good etiquette can insure that quality degrades gracefully rather than abruptly [3-5].

Protecting Broadcast Transmissions

The NPRM lists several methods through which secondary devices can determine when it is safe to transmit. It is not yet clear whether all are practical in reasonable scenarios. Research is underway at Carnegie Mellon University and elsewhere to evaluate the more complex schemes for opportunistic access to spectrum. However, it is clear that some practical methods do exist today.

1. Professional installation is clearly a viable option. It might be practical for broadband connections to WISPs, although it is not practical for Wifi-like applications. Installers can make sure that transmissions would not currently interfere with TV, and that installation data is entered in a publicly accessible database so that future interference problems can easily be resolved.
2. Another of today's options is to require that devices have GPS receivers, and that they regularly check a database with TV coverage area information. The devices must cease transmissions if they have not checked the database within a given period. The FCC should not choose a period that is too short. Changes in coverage area will presumably be infrequent, and will be known well in advance. It might be sufficient to check every week or two, for example.

As long as some schemes are practical today, the FCC has the option of allowing the underlay, while we continue to study the technical and policy issues of the more complex schemes.

The Radio Traffic Signal

I also propose that the FCC consider a new kind of device for use in the underlay: a *radio traffic signal* (RTS). The device would sense the environment, perhaps with a GPS receiver, a timeclock, and/or other devices. If it is currently safe to transmit in the TV band, the device would periodically transmit a "green light" signal to neighboring devices, at relatively low power. Thus, only this one device would have the ability to determine when it is safe to transmit. By limiting to one the number of devices that must have the sensors and processing ability to judge when it is safe to transmit, we have reduced overall cost. We have also relieved battery-powered mobile and portable devices from this task.

This approach is consistent with use by a WISP, because the WISP could easily transmit the latest changes in TV coverage areas to the RTS, which would be integrated with the consumer's transceiver and gateway. The RTS would receive but not transmit until this coverage information

has been received. When the RTS can transmit, it would send the signal that would allow other nearby devices to transmit as well.

If GPS-based systems are someday replaced with sophisticated devices that measure and react to interference temperature, the RTS would be replaced, but the other devices could be unaffected. An RTS must be certified by the FCC before it can be sold and facilitating incremental changes in unlicensed used of the band.

Summary

Broadcast TV and radio bands are well-suited for an underlay. Although plans to bring Wifi-like devices into this underlay are unlikely to succeed, there are other applications that may flourish in an unlicensed underlay to TV Broadcasters. With the appropriate rules of operation, one contender is broadband connectivity to wireless Internet service providers. This could be a tremendous social benefit in those areas that are not well served by DSL or cable modems.

There are some practical approaches to an underlay that could provide sufficient protection for TV broadcasters and consumers. Some other approaches under consideration are still unproven, and require more research. With an incremental approach, the FCC could allow the former, and consider the latter in the future. I have also proposed that a new device, a *radio traffic signal*, be considered as a means of protecting broadcast signals from underlay devices.

References

[1] J. M. Peha, "Spectrum Management Policy Options," *IEEE Communications Surveys*, Fourth Quarter 1998. [2] J. M. Peha, "Approaches to Spectrum Sharing," *IEEE Communications*, to appear.

[3] D. P. Satapathy and J. M. Peha, "Spectrum Sharing Without Licensing: Opportunities and Dangers," in *Interconnection and the Internet: Selected Papers From the 1996 Telecommunications Policy Research Conference*, 1997, pp. 49-75. Available at www.ece.cmu.edu/~peha/papers.html

[4] D. P. Satapathy and J. M. Peha, "A Novel Co-existence Algorithm for Unlicensed Variable Power Devices," *Proc. IEEE International Conference on Communications* (ICC), June 2001, pp. 2845-9. Available at www.ece.cmu.edu/~peha/papers.html

[5] J. M. Peha, "Wireless Communications and Coexistence for Smart Environments," *IEEE Personal Communications,* Vol. 7, No. 5, Oct. 2000, pp. 66-8.

(References are available at www.ece.cmu.edu/~peha/papers.html)